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OBSERVATIONS ON THE GEOLOGY OF ADJACENT PARTS OF OKLAHOMA AND NORTH WEST TEXAS.

BY E. D. COPE.

Through the coöperation of certain members of the Academy I was enabled to make an expedition in the interest of vertebrate paleontology during the summer of 1893. The gentlemen who contributed the means for this exploration were Mr. Charles Cramp, Gen. Isaac J. Wistar, Dr. Samuel Dixon, Mr. Thos. H. Savery and Mr. William Sellers. I had the privilege of the society and assistance of Prof. Amos P. Brown, in charge of the Department of Geology and Mineralogy in the University of Pennsylvania. The expedition left Bismark, Dakota, July 10th, and completed its labor at Galena in southwestern Missouri on September 4th.

The month of July and thirteen days of August were occupied in explorations in the Standing Rock and Cheyenne River Sioux Reservations in North and South Dakota. Near Fort Yates, N. D., we examined the hills which are directly to the north of the fort and extend northward. We obtained from them several fossils which indicate their marine origin, and that they belong to the Fox Hills epoch of Meek and Hayden. These include sharks' teeth of the genera *Galeocerdo* and *Otodus*, and a fragment of a probable Chimerid fish. The bluffs of the eastern escarpment of the Laramie formation extend across the plain at a distance of twelve miles west of Fort Yates, and these were explored without result, except the discovery of a few fragments of Dinosaurian bones.

We made an expedition to the Laramie bluffs which border Hump Creek in the northern part of South Dakota. This stream rises in North Dakota, and after a course of perhaps thirty miles it flows into the Ree (or Grand) River. Its valley is bounded by bad land bluffs, but in only one portion of these did we find vertebrate fossils. I owe my knowledge of this locality, as well as that which I had previously visited in 1892, to Miss Mary Collins, who has spent much of her life as a missionary among the Sioux, and who has the confidence of these people in a marked degree. One of Miss Collins' assistants, a Sioux named Maza (Iron), had observed the fossils, and served as my guide during both the expeditions which I have made to obtain them. As a trustworthy, amiable, and helpful man Maza proved himself to be an invaluable adjunct to the party. We returned from Hump Creek on August 2d, and on the way to the fort examined the escarpment of the Laramie at a point further south than previously, and had greater success in obtaining fossils. Altogether we obtained in the Laramie, bones of three species of fishes and twelve species of reptiles; but no mammals or birds rewarded our search.

Our next points of investigation were the Upper Permian bad lands of the Cimarron in Oklahoma, and such other outcrops of the formation south of that river as should promise favorable results of exploration. On our way thither we found ourselves, on August 10th, at Sioux City, Iowa. Here we were courteously entertained by Mr. John H. Charles, President of the Missouri River Transportation Company. He presented to the Academy portions of the vertebral columes of two species of Plesiosauridæ, from the Pierre formation of the Upper Cretaceous, which were new to science, and which I have described in the Proceedings of the American Philosophical Society as *Embaphias circulosus* and *Elasmosaurus intermedius*. On an excursion along the bluffs bounding the valley of the Sioux river we observed the eastern extension of the Niobrara Cretaceous limestone and chalk, and the superimposed loess.

In the absence of a good point for fitting out an expedition for the explorations on the Cimarron River, we went to Fort Supply, a considerable distance to the southward of it. We were there entertained by the officers of the post, especially by Captain William Ahman and by Lieut. Fox. The officer in command, Col. Daingerfield Parker, very kindly gave us the use of the post ambulance, and by this means we were enabled to make a pretty complete examination of the neighborhood during the days of our sojourn. Our first object was to examine the red bluffs of Permian or Trias, which bound the canyons N. and N. W. of the post, which form part of the drainage system of the Cimarron. These bluffs we examined at various points and for considerable distances, but without obtaining any traces of fossil remains, excepting some fragments of wood. We found that the formation which constitutes the higher levels at the heads of the canyons tributary to the Cimarron, is an impure friable calcareous limestone of evidently lower cretaceous age. We obtained from it *Exogyra texana* and *Gryphæa pitcherii* with other species, which have been determined by Prof. Brown as follows:—*Exogyra texana, Gryphæa pitcherii, Ostrea subovata, Ostrea ?crenulimargo, Ostrea* sp., *Cucullæa terminalis, Neithea occidentalis, Plicatula incongrua, Trigonia* sp., *Trigonia emoryi, Turritella seriatimgranulata, Schlœnbachia peruviana.*

We found also the following vertebrata: *Lamna No. 1, Lamna No. 2,* Lepidotid scale, *Uranoplosus arctatus, U. flectidens, Coelodus brownii, Plesiosaurus* vertebrae, crocodile fragments, and fragments of a tortoise.

The three species of Pycnodont fishes were new to science, and they have a Lower Cretaceous facies. *Plesiosaurus* is represented by dorsal vertebrae only, but these are not of the Upper Cretaceous type. I have never found Lepidotid fish remains in the Upper Cretaceous of North America, while they are characteristically Lower Cretaceous and Jurassic in Europe. The only occurrence of Lepidotid fishes so far recognized in N. America, is based on some teeth sent by Mr. Charles H. Sternberg in the Dakota sandstone of Kansas, and on the new species, *Macrepistius arenatus,* from the Trinity bed of Texas discovered by Prof. R. T. Hill. (See Journal of the Academy Vol. IX, Part 4). The crocodilian remains are undeterminable.

Below this formation, which is of a strong yellow color and about twenty-four feet thick, is a stratum of marls, black above, whitish in the middle, and buff below, of about equal thickness with the limestone. The black color is due to carbon, which is some places forms thin layers of impure coal. This formation contained no fossils by which its age could be determined, and thus stood in strong contrast with the cretaceous above it, and agreed with the red beds of the Permian below it. Between the black marl and the cretaceous there intervened at some points a shallow bed of sand, usually coarse, and reaching in places a thickness of six feet. Its color is yellow, varied with horizontal red streaks. The age of the marine Cretaceous beds corresponds, according to Prof. Brown's determination, with the Comanche Peak terrane of the Texas geologists. The tract first observed lies about five miles northwest of Fort Supply, and is of limited extent, being cut off to the north by the drainage ot the Cimarron River, and to the south by the drainage of the North Fork of the Canadian. Its horizontal extent cannot exceed fifty square miles. We examined another and more limited area of the same bed which contained the same invertebrate fossils, at a point about twelve miles south of the fort.

The Permian red beds are traversed conformably by layers of gypsum at different horizons. The sand bed below the cretaceous limestone is sometimes consolidated into a sandstone, which forms a ledge near the summit of the bluffs. From fifty to seventy-five feet below this and in the red beds, is a bed of saccharoidal limestone. This limestone is luminous when struck or scratched with a metallic object, like a similar limestone which occurs in some of the silver mines in Utah in the Wasatch Mountains.

At the locality already referred to, twelve miles south of Fort Supply on a low ridge of the Cretaceous terrane, we observed a white discoloration, as though two or three cartloads of a chalky material had been deposited there. Prof. Brown was so fortunate as to find in it the fragments of a solitary superior molar tooth of *Protohippus perditus*, which determined the age of the material as the Loup Fork, or Upper Miocene. Careful search failed to reveal another fossil, and it is evident that we have here the last remnants of a formation which has been almost entirely removed by erosion.

With the view of further determining the extent of the Comanche and Loup Fork formations, we left Fort Supply and went by rail to Miami, which is a village in Roberts County of the Panhandle of Texas, south of the Canadian river. For several miles before reaching Miami, the railroad runs between steep bluffs, which form the southern border of the flood plains of the Canadian river, and are the escarpments of the outlying tracts and fingers of the Staked Plains. They are about two hundred feet in elevation, and include two hard strata, while the great mass is sandy clay, or sand in a few localities. One of the indurated beds is at the summit of the bluffs, forming the surface of the plain, and is about six feet in thickness. The softer argillaceous bed below it varies from fifteen to fifty feet, when the second impure sandstone is reached, which has a thickness of about eight feet. The one hundred and fifty feet below this is friable, so that the construction of the escarpment is such as to keep it more or less perpendicular. The general appearance of the bluffs is closely similar to that of the Blanco beds at the typical locality one hundred and fifty miles south, at the point where the Brazos River issues from the Staked Plains in the Blanco Canyon. In order to ascertain whether this formation is the Blanco or the Loup Fork, which it resembles, we examined the bluffs for a day and a half for fossils. They are rare in that region, but I obtained on the second day, teeth of both series of a horse, *Equus cumminsii* Cope, which demonstrated at once that the age is the Blanco. Mr. Brown found camel bones which approach in dimensions those of the Blanco species, rather than those of the Loup Fork ; but the species could not be identified.

On the succeeding day, we drove, thanks to Mr. R. T. Cole, of Mobeetie, to the town of Mobeetie in Wheeler County, eighteen miles S. E. of Miami. The route takes the traveler across a part of the Staked Plains, and a considerable distance before Mobeetie is reached, ravines belonging to the drainage system of the tributaries of the Red River are passed. We examined a number of these for considerable distances without obtaining fossils. As we passed the deserted Fort Elliott, near to Mobeetie, I examined some sandy beds like those of the Upper Blanco beds, and obtained additional tooth fragments of *Equus cumminsii* and a second species of *Equus* probably *E. eurystylus*, and fragments of teeth and other bones of undeterminable camels. We thus determined the extension of the Blanco bed as far east as Mobeetie.

The result of my observations on this, the northeastern border of the Staked Plains, is to the effect that this plateau to the north of the Red River like that part to the south of it, belongs to the Blanco deposit, giving the latter a north and south extent of two hundred and fifty miles. It had been hitherto positively determined at the typical locality only, that distance south of Miami, on the upper waters of the Brazos. From this point to the Red River the formation appears to be continuous; and the portion north of the Red River now described, not only has a close physical resemblance to the portion south of it, but contains as now appears, fossils of the same age. (See Report of the Geological Survey of Texas for 1892, for reports by Cummins and Cope on the Blanco terrane).

On our return from Texas, we stopped at Tucker, Oklahoma, near to the Cimarron River, and examined for a day the exposures and bad lands of the Upper Permian of that region. Although the exposures are most favorable for the exhibition of any fossils which the strata may contain, nothing of organic origin was found. Crystallized gypsum is very abundant.

On reaching Kansas on our return, we stopped at Wellington and examined the Plistocene sands of that locality. At the west side of the town is an abandoned sand quarry, and on the east side is a similar quarry, from which the town derives its supply of building sand. We obtained from a saloon a number of fossils which were said to have been found several years previously in the west-side quarry. These consist of an almost entire mandibular arch of an adult *Elephas primigenius* with both molars in place, with several bones of probably the same animal; together with the muzzle and parts of both horns of a large bison, which differs considerably from *B. latifrons*, and to which I have given the name of *Bos crampianus*. It is figured and described in the Journal of the Academy, Vol. IX, Part 4. I also obtained from Mr. Wheeler, owner of the east-side quarry, an entire posterior molar of *Elephas primigenius* of the coarse plated variety, which was taken from his pit.

Hearing of remains of the Mammoth in possession of some one near to Hennessy in Central Oklahoma, we took rail for that place. On arriving, we found that the fragments were in possession of a rancher eight miles west of that town. We visited the ranch, and found that the fragments were much broken, and included the four molar teeth of an adult *Elephas primigenius* of the coarse plated variety. The rancher, Mr. Painter, had in his possession a number of teeth and some bones of the limbs of a saber-tooth tiger, which he had found with those of the mammoth. Both its bones and those of the mammoth were stained red by the coloring iron of the Permian clay, and were covered by a thin layer of it. The animals had been in some way buried in this material during the Plistocene epoch. I have described the cat under the name of *Dinobastis serus* in the Journal of the Academy, Vol. IX, Part 4, as it represented both a species and genus new to science.

On our return northward we stopped a few days at Galena, Missouri, and visited the Marble cave eighteen miles east of that place, under the guidance of the proprieter, Mr. Truman Powell. I wish here to express the obligation under which Mr. Powell placed me through his hospitality and general assistance.